Calibration of OxTS products

Version: 140221
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1. Introduction

This document aims to give a complete overview of the calibration of OxTS products.

1.1. What is an instrument?

Equipment that can be used to make measurements is an instrument. A ruler is a basic instrument that can make scalar measurements of length. The OxTS inertial and GPS navigation systems are instruments that make many vector measurements including acceleration, velocity, position, angular acceleration, angular rate, orientation and other quantities derived from these basic vector quantities.

1.2. What is calibration?

In general the calibration of an instrument means checking that the instrument is able to measure to a predefined level of accuracy, i.e. that the instrument works within a certain tolerance. Part of calibration may involve making adjustments to optimise the performance of the instrument and then re-checking that the instrument still meets its accuracy requirements.

Instruments may be checked before adjustment to give confidence that all the data collected since the last check are accurate.

Instruments are adjusted to bring them into tolerance or to improve them to a new level of accuracy. For many instruments it is not necessary to adjust them if they pass their initial check. At OxTS we always adjust the instruments because we want to make sure that they are in the best condition for inertial navigation.

Instruments have another check after adjustment to make sure that the adjustment has worked and to verify that they are within tolerance.

1.3. What is a laboratory?

A laboratory is an organisation (or part of an organisation) that is able to perform calibrations.

1.4. What is ISO 17025

ISO 17025 is a set of requirements for laboratories. When followed they ensure that the laboratory is able to check an instrument to a given tolerance under certain conditions. In the case of ISO 17025 the measurements are traceable to national standards.

1.5. What is accreditation?

It is possible to work to ISO 17025 without anyone checking that you meet the standard. Accreditation is when you have been audited and found, by an accreditation body, to meet the standard of ISO 17025. In the UK UKAS is the only accreditation body.

For OxTS, accreditation by UKAS means that we have been assessed against ISO 17025 to demonstrate our competence, impartiality and performance capability. UKAS accreditation means the laboratory can show to its customer that it has been successful at meeting the requirements of ISO 17025. This means that the customer reduces the risk of selecting an incompetent laboratory and paying for, or more seriously acting on, invalid results.

1.6. Can other laboratories calibrate the OxTS products?

OxTS is not aware of any other companies who can assess the performance of the OxTS products.

No other companies are able to make adjustments to the OxTS products since the adjustment constants need to be programmed into the inertial measurement unit by special software. OxTS has not released this software to anyone else.

1.7. What are the ISO 17025 accredited calibration capabilities of OxTS?

Currently OxTS is only accredited to check that the acceleration vector and the angular rate vector are within tolerance. Other measurements, such as velocity, position and orientation are not covered by our ISO 17025 accreditation.

1.8. How do you verify the accreditation status of OxTS?

UKAS provides a complete list of all laboratories that it accredits so that customers can independently verify that we have been accredited. Visit webpage:

http://ukas.org/calibration/labsearch.asp

and enter our laboratory number, which is **4647**. This will show that OxTS (Oxford Technical Solutions Ltd.) is accredited.

1.9. Calibration version

The information in this document has been prepared using the calibration processes that were in place during August 2011. This document may not be kept up to date with every change in the calibration. If you find any differences then please email support@oxts.com and we will be happy to explain differences to you.

2. Calibration of OxTS products

Only some OxTS products can be calibrated. The following table lists the product families and the calibration types that are available.

Product family	Basic calibration	ISO 17025 calibration	SuperCAL
RT2000 (RT2500, RT2502, etc.)	Yes	Yes	Yes
RT3000 (RT3002, RT3003, etc.)	Yes	Yes	Yes
RT4000 (RT4002, RT4003, etc.)	Yes	Yes	Yes
Inertial+ (Inertial+2, Inertial+ 250, etc.)	Yes	Yes	Yes
Survey+ (Survey+2, Survey+ 250, etc.)	Yes	Yes	Yes
RT-ANA	Yes	No	N/A
RT-Base	No	No	N/A
GPS-Base	No	No	N/A
RT-Range	N/A	N/A	N/A
RT-UPS	No	No	N/A

2.1. RT, Inertial+, and Survey+ Calibrations

There are two options for calibration of the RT (RT2000, RT3000 and RT4000), Inertial+ and Survey+ product families, the basic calibration and the ISO 17025 calibration. The optional SuperCAL can be added to each calibration.

The steps in each calibration are given in the table below.

Steps in calibration process	Basic calibration	ISO 17025 calibration
Customer property receipt	Yes	Yes
Inbound test	Yes	Yes
Pre-calibration assessment and report		Yes
Firmware upgrade	*If under support*	*If under support*
SuperCAL adjustment	*If ordered*	*If ordered*
Adjustment	Yes	Yes
Calibration assessment	Yes	Yes
Basic calibration certificate	Yes	
ISO 17025 calibration certificate		Yes
Temperature soak test	Yes	Yes
Final test	Yes	Yes

Basic and ISO17025 calibrations adjust the instrument to within the same tolerances. A SuperCAL adjustment can be added to either calibration process to improve the performance of the gyros.

2.1.1. Customer property receipts

When the package is received at OxTS an engineer will note down all of the contents of the package and clearly mark the goods as being property of the customer and not the property of OxTS.

2.1.2. Inbound test

The inbound test checks the operation of the inputs and outputs of the product to ensure that they are all working correctly. The test also checks the basic operation of the GPS and the inertial measurement unit to ensure that they can produce a stable output while the product is stationary.

The following ports are checked.

Port	Test description
GPS	Test that the GPS is receiving data correctly from an antenna.
Second GPS	Test that both GPS receivers can work together and an ambiguity search can be started.
RS232	Check that the input to the product and the output from the product are working correctly by connecting the product to a serial port on a PC.
Ethernet	Check that the Ethernet port is working correctly by sending and receiving data on the Ethernet port of the product.
CAN	Check that data is output by the CAN port of the RT.
DGPS	Check that the input to the product and the output from the product are working correctly by connecting the product to a serial port on a PC.
1PPS	Check that the 1PPS output is working correctly.
Event Input	Check that the event input is working correctly.
Wheel speed output	Check that the wheel speed output is working correctly.
Wheel speed input	Check that the wheel speed input is working correctly.
IMU Sync (100Hz or 250Hz)	Check that the IMU sync output is working correctly.
Ground Pins	Check that all the ground pins are connected and have not been broken.

In addition, the configuration files and IP address will be saved so that they can be restored after the final test.

2.1.3. Pre-calibration assessment

During the pre-calibration assessment the product will be put on our calibration table and it will undergo a check-run. The check-run is the final part of the calibration assessment and it will verify whether the system is within tolerance or not.

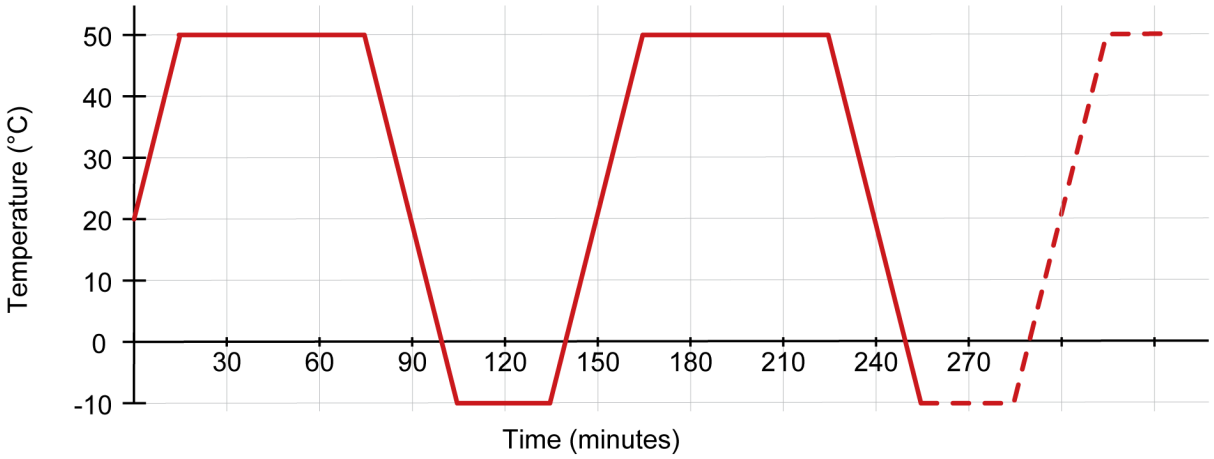
A pre-calibration assessment document will be made. This has the same fields as the normal calibration certificate and the fields covering this report are discussed in the section on the calibration certificate below.

2.1.4. Firmware upgrade

There are four or five microprocessors in the system. If the system is covered by OxTS Support then the firmware will be updated to the latest standard that the hardware can support. Systems not covered by support will be left with their older firmware.

2.1.5. Temperature soak test

The temperature soak test checks that the product remains functional while the temperature is changed rapidly. The products are tested in the temperature chamber for at least 12 hours, normally 15 hours. During this time the temperature profile in the figure below repeats, giving more than 4 cycles.



During the temperature soak test the output of the product is monitored to make sure the internal electronics are operating correctly.

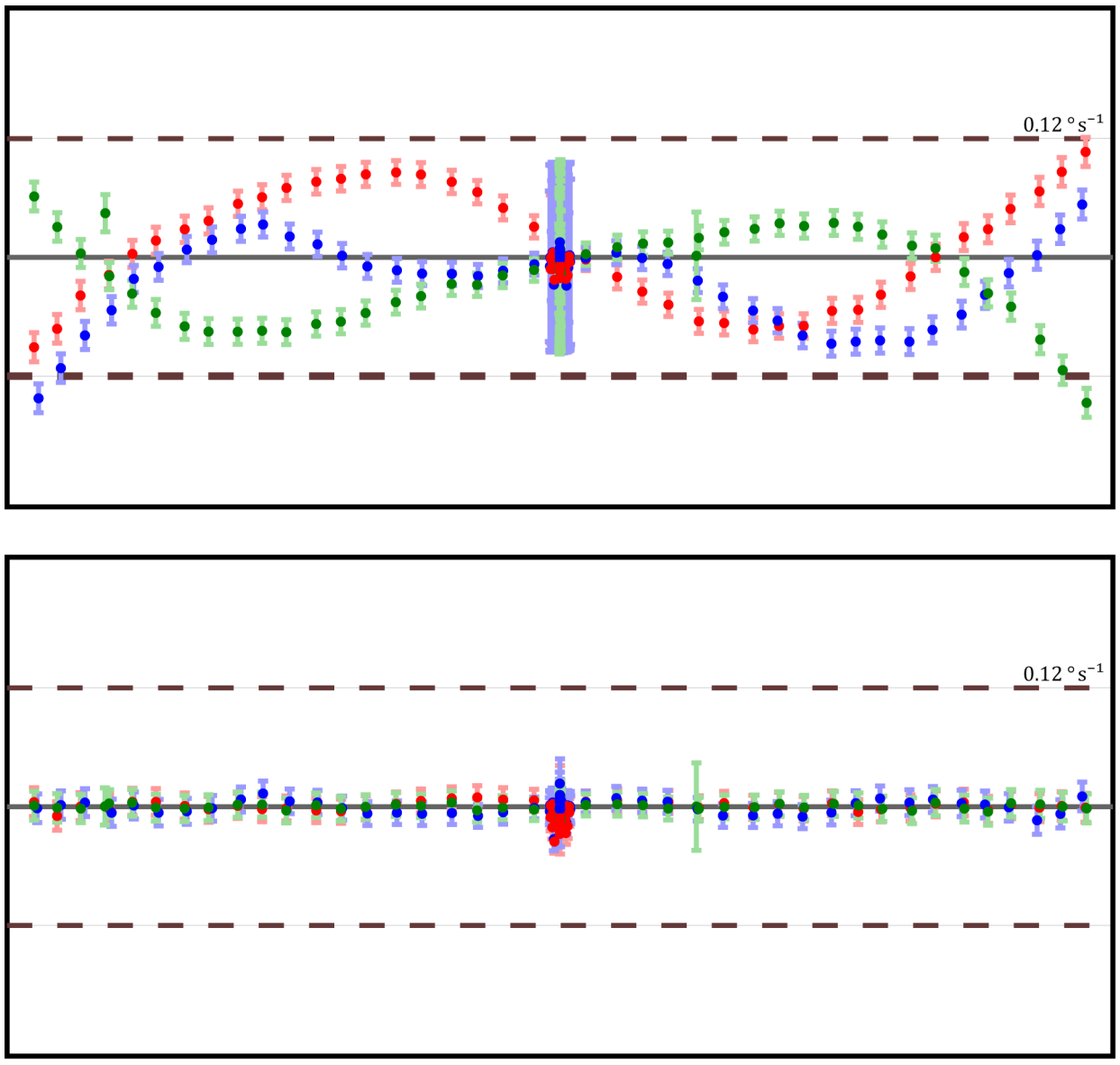
2.1.6. SuperCAL adjustment

SuperCAL is a process whereby the linearity of the angular rate sensors (gyros) can be improved. After SuperCAL the gyro linearity is better than 0.05%. This performance level easily achieves the performance required for tests that need 0.1% accuracy for angular rate.

In general SuperCAL does not improve the performance of inertial navigation system since the Kalman filter is able to compensate for the gyro linearity errors. For some specific tests there is a benefit to slip angle in having SuperCAL. These include:

- J-turns
- Steady-state circle tests

Some inertial measurement units do not meet the strict requirements of the normal calibration and these will automatically have SuperCAL performed on them.
The plot below shows the difference that SuperCAL makes to the gyro linearity. The top graph shows the angular rate errors before SuperCAL and the bottom graph shows them afterwards.



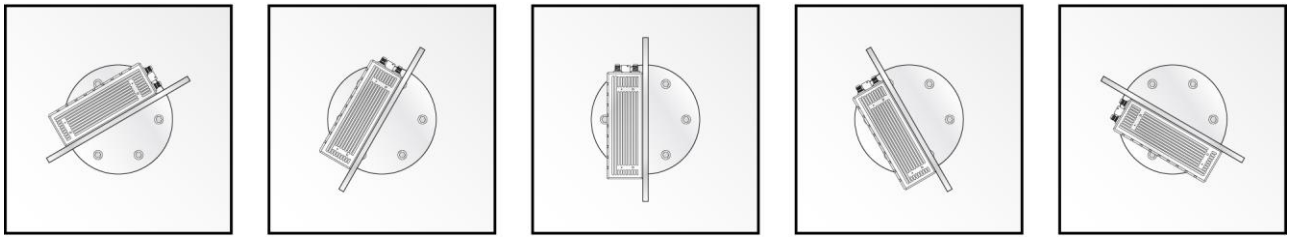
The y-axis of the graphs is the average angular rate error, the dotted line shows the y-axis scale at 0.12°/s. The x-axis is the average input angular rate from about -80°/s to +80°/s. This particular inertial measurement unit has had to have SuperCAL automatically because it would not pass the basic calibration without it; most inertial measurement units do not need SuperCAL and have all of their measurements below 0.12°/s. They still show better performance after SuperCAL.

2.1.7. Adjustment

The purpose of adjustment for the RT, Inertial+, and Survey+ products is to adjust the axes of the accelerometers so that they are 90° apart (orthogonal). It also aligns the axes of the angular rate sensors so that they are the same as the axes of the accelerometers. It is not possible to manufacture the inertial measurement unit so that the sensors are perfectly aligned to the orthogonal axes. The adjustment is done through software in the microprocessor on the inertial measurement unit.

Part of the adjustment also makes sure that the scale factor and bias of each sensor is set correctly. In our opinion, the Kalman filter is able to estimate the scale factor and bias during operation so these quantities are not critical to the performance of the product.

To calibrate the accelerometers we use a "tumble test". In this test the inertial measurement units is angled at many different orientations and the accelerometers measure the acceleration due to gravity. At each angle each accelerometer sees a different value of acceleration but the combined acceleration from all three accelerometers should always be 1g. The figure below shows several different positions about one axis.



In our tumble test the system is rotated about two axes, giving full coverage for each accelerometer in the gravity field. For the adjustment test about 200 different orientations are used and the result is a best fit of the results. The matrix that turns the accelerometer outputs into an orthogonal set is computed as well as the bias for each accelerometer. These adjustments are then programmed into the inertial measurement unit.

To calibrate the angular rate sensors we look at the rotation between each acceleration measurement. The rotations between each orientation are arranged to be about 120° and the exact angle can be found by looking at the (now calibrated) acceleration measurements. This is compared to the angle given by integrating the angular rate sensors. We search for the best adjustment matrix and bias and these are then programmed into the inertial measurement unit.

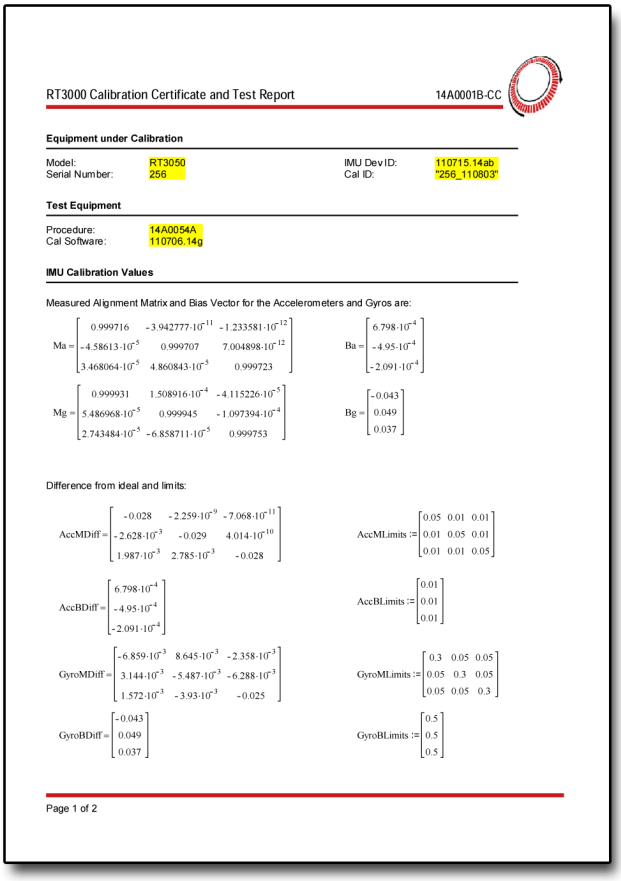
2.1.8. Calibration assessment

The calibration assessment makes sure that the adjustment has worked correctly. It measures the axes of the accelerometers and angular rate sensors and checks that they are in tolerance. It checks that the bias and scale factor of the sensors are within tolerance.

For the ISO 17025 calibration the calibration assessment also checks that the accelerations and angular rates are within tolerance over a range of input values. The technique used for the check is the same as the technique used for the adjustment. Now that the inertial measurement unit has been adjusted any new adjustment that is computed from the calibration assessment is considered to be an error. We check that the errors during the calibration assessment are within tolerance.

2.1.9. Basic calibration certificates

The basic calibration certificate contains information from the calibration assessment without any acceleration or angular rate measurements. It is simply the adjustment matrix, the error during the check and a statement saying that we believe the system works correctly. An example basic certificate is shown in the figure below.



RT3000 Calibration Certificate and Test Report 14A0001B-CC

Equipment under Calibration

Model: RT3050
Serial Number: 256
IMU Dev ID: 110715.14ab
Cal ID: "256_110803"

Test Equipment

Procedure: 14A0054A
Cal Software: 110706.14g

IMU Calibration Values

Measured Alignment Matrix and Bias Vector for the Accelerometers and Gyros are:

$$Ma = \begin{bmatrix} 0.999716 & -3.942777\cdot10^{-11} & -1.233581\cdot10^{-12} \\ -4.58613\cdot10^{-5} & 0.999707 & 7.004898\cdot10^{-12} \\ 3.468064\cdot10^{-5} & 4.860843\cdot10^{-5} & 0.999723 \end{bmatrix} \quad Ba = \begin{bmatrix} 6.798\cdot10^{-4} \\ -4.95\cdot10^{-4} \\ -2.091\cdot10^{-4} \end{bmatrix}$$

$$Mg = \begin{bmatrix} 0.999931 & 1.508916\cdot10^{-4} & -4.115226\cdot10^{-5} \\ 5.486968\cdot10^{-5} & 0.999945 & -1.097394\cdot10^{-4} \\ 2.743484\cdot10^{-5} & -6.858711\cdot10^{-5} & 0.999753 \end{bmatrix} \quad Bg = \begin{bmatrix} -0.043 \\ 0.049 \\ 0.037 \end{bmatrix}$$

Difference from ideal and limits:

$$AccMDiff = \begin{bmatrix} -0.028 & -2.259\cdot10^{-9} & -7.068\cdot10^{-11} \\ -2.628\cdot10^{-3} & -0.029 & 4.014\cdot10^{-10} \\ 1.987\cdot10^{-3} & 2.785\cdot10^{-3} & -0.028 \end{bmatrix} \quad AccMLimits := \begin{bmatrix} 0.05 & 0.01 & 0.01 \\ 0.01 & 0.05 & 0.01 \\ 0.01 & 0.01 & 0.05 \end{bmatrix}$$

$$AccBDiff = \begin{bmatrix} 6.798\cdot10^{-4} \\ -4.95\cdot10^{-4} \\ -2.091\cdot10^{-4} \end{bmatrix} \quad AccBLimits := \begin{bmatrix} 0.01 \\ 0.01 \\ 0.01 \end{bmatrix}$$

$$GyroMDiff = \begin{bmatrix} -6.859\cdot10^{-3} & 8.645\cdot10^{-3} & -2.358\cdot10^{-3} \\ 3.144\cdot10^{-3} & -5.487\cdot10^{-3} & -6.288\cdot10^{-3} \\ 1.572\cdot10^{-3} & -3.93\cdot10^{-3} & -0.025 \end{bmatrix} \quad GyroMLimits := \begin{bmatrix} 0.3 & 0.05 & 0.05 \\ 0.05 & 0.3 & 0.05 \\ 0.05 & 0.05 & 0.3 \end{bmatrix}$$

$$GyroBDiff = \begin{bmatrix} -0.043 \\ 0.049 \\ 0.037 \end{bmatrix} \quad GyroBLimits := \begin{bmatrix} 0.5 \\ 0.5 \\ 0.5 \end{bmatrix}$$

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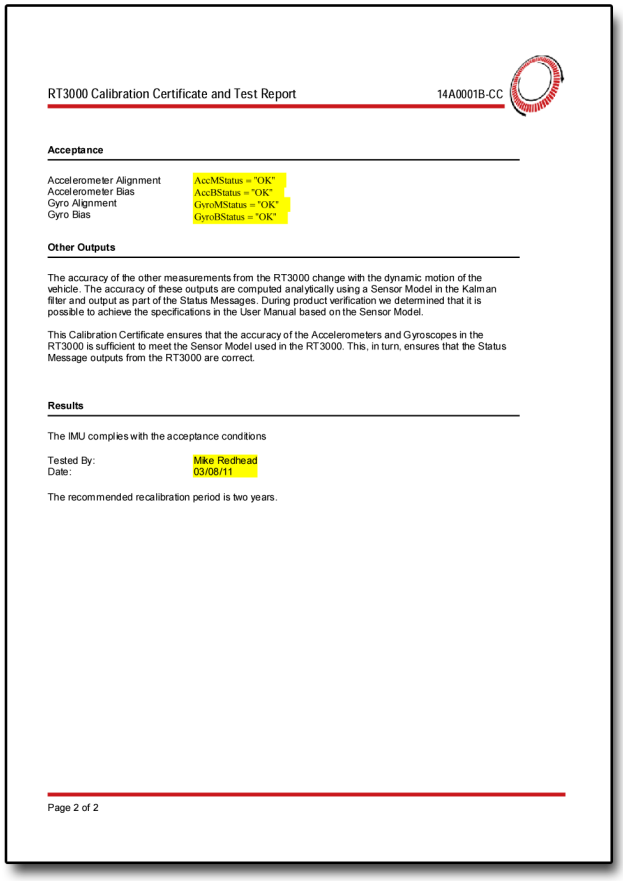

RT3000 Calibration Certificate and Test Report 14A0001B-CC

Acceptance

Accelerometer Alignment AccMStatus = "OK"
Accelerometer Bias AccBStatus = "OK"
Gyro Alignment GyroMStatus = "OK"
Gyro Bias GyroBStatus = "OK"

Other Outputs

The accuracy of the other measurements from the RT3000 change with the dynamic motion of the vehicle. The accuracy of these outputs are computed analytically using a Sensor Model in the Kalman filter and output as part of the Status Messages. During product verification we determined that it is possible to achieve the specifications in the User Manual based on the Sensor Model.

This Calibration Certificate ensures that the accuracy of the Accelerometers and Gyroscopes in the RT3000 is sufficient to meet the Sensor Model used in the RT3000. This, in turn, ensures that the Status Message outputs from the RT3000 are correct.

Results

The IMU complies with the acceptance conditions

Tested By: Mike Redhead
Date: 03/08/11

The recommended recalibration period is two years.

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The fields in the basic calibration certificate are described in the table below.

Field	Description
14A0001B-CC	This is the version number of the calibration certificate template.
Model	This is the model of the product being calibrated.
IMU Dev ID	This is the software version that is running in the inertial measurement unit (IMU).
Serial Number	This is the serial number of the product being calibrated.
Cal ID	This is the calibration identifier that has been programmed into the inertial measurement unit. It allows the engineers at OxTS to verify which adjustment constants are stored.
Procedure	This is the internal work instruction procedure that was followed to adjust and assess the product.
Cal Software	This is the version of software that was used to compute the adjustment constants and to assess the performance of the product.
Ma	The Ma matrix is the matrix that transforms the outputs of the accelerometers so that they are along an orthogonal set of axes. This matrix includes the scale factor (gain) adjustment for the accelerometers.
Ba	The Ba vector is the bias adjustment that needs to be made to the accelerometers.
Mg	The Mg matrix is the matrix that transforms the outputs of the angular rate sensors (gyros) so that they are along the same orthogonal set of axes as the accelerometers. This matrix includes the scale factor (gain) adjustment for the angular rate sensors.
Bg	The Bg vector is the bias adjustment that needs to be made to the angular rate sensors.
AccMDiff	The AccMDiff matrix is error matrix that comes from the assessment of the accelerometers. The diagonal elements are expressed as a percentage. The off-diagonal elements are expressed in degrees.
AccMLimits	The AccMLimits matrix contains the limits for each element in the AccMDiff matrix. If any item in the AccMDiff matrix is larger than the element in the AccMLimits matrix then the inertial measurement unit has not passed.
AccBDiff	The AccBDiff vector contains the error in the bias of the accelerometer during the assessment. The values are in m/s^2.
AccBLimits	The AccBDiff vector contains the limits for the AccBDiff vector.
GyroMDiff	The GyroMDiff matrix is the error matrix that comes from the assessment of the angular rate sensors. The diagonal elements are expressed as a percentage. The off-diagonal elements are expressed in degrees.
GyroMLimits	The GyroMLimits matrix contains the limits for each element in the GyroMDiff matrix.
GyroBDiff	The GyroBDiff vector contains the error in the bias of the angular rate sensors during the assessment. The values are in degrees/s.
GyroBLimits	The GyroBLimits vector contains the limits for each element in the GyroBDiff vector.
Accelerometer Alignment, AccMStatus	The accelerometer alignment status shows whether the accelerometer alignment (and scale factor) has passed (OK) or failed.
Accelerometer Bias, AccBStatus	The accelerometer bias status shows whether the accelerometer bias has passed (OK) or failed.
Gyro Alignment, GyroMStatus	The gyro alignment status (or angular rate sensor alignment status) shows whether the angular rate sensor alignment (and scale factor) has passed (OK) or failed.

Gyro Bias, GyroBStatus	The gyro bias status (or angular rate sensor bias status) shows whether the angular rate sensor bias has passed (OK) or failed.
Tested By	This is the name of the engineer who tested the product. It serves as a signature.
Date	This is the date when the product was tested.

Although the certificate states a recommended recalibration period the customer should choose their own period depending on their own internal quality procedures.

2.1.10. ISO 17025 calibration certificates

The ISO 17025 calibration contains a much more detailed assessment of the performance of the product. It also contains all the traceability information for the equipment and environment used for the assessment. The document is several pages long and an example copy is attached to the end of this document. The attached document has some missing fields since it was generated before OxTS was fully ISO 17025 compliant.

The definitions for some of the fields in the ISO 17025 calibration certificate are described in the tables below. The tables are divided into the sections of the calibration certificate. The fields for section 1, Overview, are described in the table below.

Field	Description
Issued by	Oxford Technical Solutions is the issuing authority for this calibration certificate. Our full company details are included in this field.
UKAS accreditation number	Our accreditation number, 4647, is shown on the certificate. This number can be used to confirm that Oxford Technical Solutions Ltd. is accredited and for other communications with UKAS.
Certificate number	This is a unique number relating to this certificate. The number is made up of the process number at OxTS (14A0054A-CC), the serial number (256), the date (yymmdd) and a sequence number for the certificate in case amendments are made.
Calibration date	This is the date when the assessment was performed. The ISO date format (year-month-day) format is used.
Calibration method	This is the method at OxTS that was used to assess the performance of the product.
End-user	Most calibrations from OxTS will be purchased through one of our representatives. Normally the end-user will still require their name and details to appear on the certificate. To conform to the requirements of ISO 17025 we list both parties on the certificate, the end user and the consignee. These terms are clearly defined in international export laws and we use the same meanings here. The example certificate is of our demonstration equipment.
Consignee	This will normally be the name of the representative who organised for the equipment to be calibrated on behalf of the end user.
Confidentiality	This states that the calibration certificate is confidential, which is a requirement of ISO 17025. OxTS will not issue copies of the calibration certificate to anyone unless their organisation is entered as the consignee or the end-user.

The fields for section 2, Calibrated Item, are described in the table below.

Field	Description
Model	This is the product model that the calibration certificate covers.
Serial number	This is the serial number of the product that the calibration certificate covers.
Condition	This is a statement on the condition of the product when it was assessed.

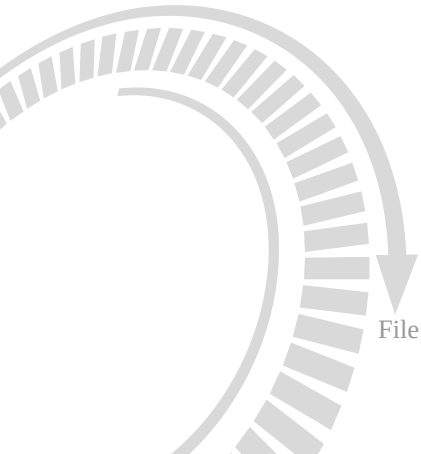
The fields for section 3, Physical Conditions, are described in the table below. There is only one physical condition that the calibration process relies on and this is the acceleration due to gravity at the OxTS offices.

Field	Description
Name	This identifies that it is gravity that is being described.
Calibration by	This identifies the organisation that performed the calibration.
Calibration ID	This is the identification on the calibration certificate.
Calibration date	This is the date when the calibration took place.
Location	This is the location where the calibration is valid.
Estimation	This is the measurement and certainty of the estimate of gravity at the location.

The fields for section 4, Equipment Used, are described in the table below.

Field	Description
Name	The name and model of the equipment used.
Serial	The serial number of the equipment used.
Calibrated by	The organisation that calibrated the equipment.
Calibration ID	The identification on the calibration certificate.
Calibration date	The date when the equipment was calibrated.
Uncertainty	The uncertainty of measurement of the equipment being used.
Version	For software this is the version of software being used.

The fields for section 5, Environmental Conditions, are described in the table below.



Field	Description
IMU frequency (Hz)	This is the frequency that the inertial measurement unit (IMU) is operating at. This should be 100 Hz or 250 Hz depending on the product being tested. It is measured using the IMU Sync output of the product. In operation the inertial measurement unit is synchronised to GPS Time. On the test table GPS is not available so it is necessary to measure the frequency so that the integration from angular rate to orientation is performed with the correct time step.
Start applied voltage (V)	This is the voltage being applied to the product at the start of the test. The product should not change its performance depending on the applied voltage but it is still measured as a condition of ISO 17025.
Final applied voltage (V)	This is the voltage being applied to the product at the end of the test. (It is measured twice.)
Start temperature (ºC)	This is the surface temperature of the product at the start of the test. The temperature probe is attached to the product to measure the temperature.
End temperature (ºC)	This is the surface temperature of the product at the end of the test.

In section 6, Validation, the results are summarised in four categories.

Field	Description
Pass	The result can be classified as a pass with a confidence in excess of 95%
Pass *	The error has a probability of between 50% and 95% of being below the limit
Fail *	The error has a probability of between 5% and 50% of being below the limit
Fail	The result can be classified as a fail with a confidence in excess of 95%

The measurement process used during the calibration of the product causes the uncertainties to vary: some measurements have higher certainty than others depending on the orientation; this is not a fault in the product, but an unavoidable limitation of the calibration process.

The fields for section 6.1, Validation, Environmental Results, are described in the table below.

Field	Description
Change	This is the change in the temperature during the test. It is important because the adjustment and assessment need to be performed at constant temperature.
Uncertainty	This is the uncertainty in the temperature measurement.
Limit	This is the limit for the temperature change during the assessment.
Result	This indicates whether the environment was suitable for the assessment or not.

The fields for section 6.2, Accelerometer Results, are described in the table below.

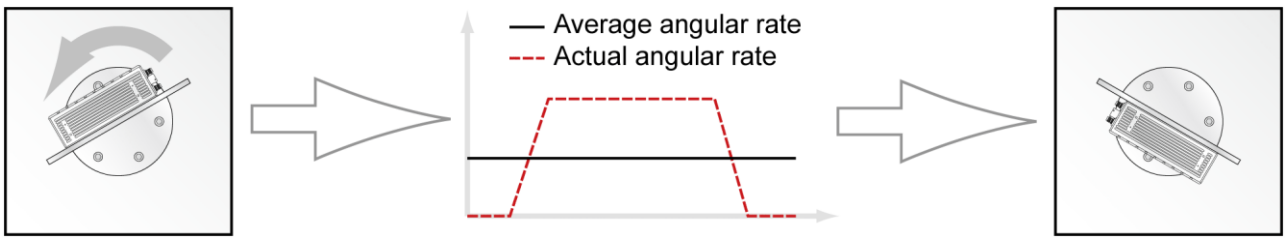
Field	Description
Input m/s²	This is the estimated input acceleration for this accelerometer.
Output m/s²	This is the measured output acceleration for this accelerometer.
Error m/s²	This is the difference between the input and the output for this accelerometer.
Uncertainty m/s²	This is the uncertainty of the measurement and it includes uncertainty from the input and the output. The uncertainty is not constant throughout the test.
Result	This indicates whether this acceleration measurement was within tolerance or not.

The results for three accelerometers are presented. Although the assessment is made using more than 40 measurements, many of them are very close to each other. The table presents a selection of measurements separated by suitable ranges.

The fields for section 6.3, Gyroscope Results, are described in the table below.

Field	Description
Input °/s	This is the estimated average angular rate for each angular rate sensor during each orientation change.
Output °/s	This is the measured average angular rate for each angular rate sensor during each orientation change.
Error °/s	This is the difference between the input and the output for each angular rate sensor during each orientation change.
Uncertainty °/s	This is the uncertainty of the measurement and it includes uncertainty from the input and the output. The uncertainty is not constant.

The angular rate measurement during the assessment is an average angular rate. The figure below explains why an average angular rate is used.



On the left, the product is orientated at 30°. Then the test table rotates to the new orientation at 150°. The accelerometers measure the two orientations. The angular rate sensors are integrated to give the new orientation from the old orientation. However, the test table cannot change from stationary to full speed instantly. Because the test table ramps its speed from stationary to full speed slowly, the average angular rate is different to the peak angular rate. There is also a significant portion of the test at zero speed; this is where the brakes that hold the orientation completely stable are removed and applied. During this time small, but significant changes in orientation can occur.

The average angular rate may imply that the product is not tested over its full range. However, the peak angular rate extends from -80°/s to +80°/s, which provides sufficient coverage.

Section 6.4, Summaries, condenses the results from the rest of section 6. It shows the single worst case for any of the tests.

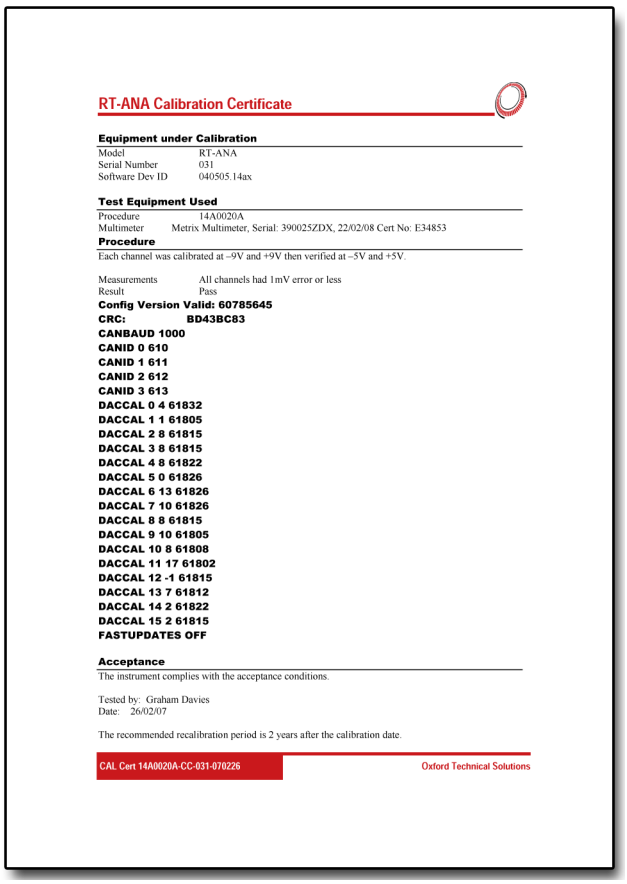
Section 7, Authorization, lists the name of the calibration technician who carried out the assessment and the date when the assessment was performed.

2.1.11. Final test

Following calibration the product has a final test. This is almost the same as the inbound test where all the inputs and outputs are tested to make sure that they work correctly. The IP address and the customer's configuration are restored to the product.

2.2. RT-ANA Calibrations

OxTS is able to perform basic calibration on the RT-ANA. This process is not covered by our ISO 17025 accreditation.



RT-ANA Calibration Certificate

Equipment under Calibration

Model RT-ANA
Serial Number 031
Software Dev ID 040505.14ax

Test Equipment Used

Procedure 14A0020A
Multimeter Metrix Multimeter, Serial: 390025ZDX, 22/02/08 Cert No: E34853

Procedure

Each channel was calibrated at –9V and +9V then verified at –5V and +5V.

Measurements All channels had 1mV error or less
Result Pass

Config Version Valid: 60785645
CRC: BD43BC83
CANBAUD 1000
CANID 0 610
CANID 1 611
CANID 2 612
CANID 3 613
DACCAL 0 4 61832
DACCAL 1 1 61805
DACCAL 2 8 61815
DACCAL 3 8 61815
DACCAL 4 8 61822
DACCAL 5 0 61826
DACCAL 6 13 61826
DACCAL 7 10 61826
DACCAL 8 8 61815
DACCAL 9 10 61805
DACCAL 10 8 61808
DACCAL 11 17 61802
DACCAL 12 -1 61815
DACCAL 13 7 61812
DACCAL 14 2 61822
DACCAL 15 2 61815
FASTUPDATES OFF

Acceptance

The instrument complies with the acceptance conditions.

Tested by: Graham Davies
Date: 26/02/07

The recommended recalibration period is 2 years after the calibration date.

CAL Cert 14A0020A-CC-031-070226 Oxford Technical Solutions

The certificate for the RT-ANA is a record of the calibration constants that were required to adjust the RT-ANA so that it output correctly. There is an acceptance statement that declares that the equipment is working to its specification.

3. Administrative information

There are additional administrative parts to calibrations that need to be considered. In general most delays happen because the paperwork is not in order before the product is ready to be shipped.

3.1. Quotations for repair work

If a fault is found with your product or it no longer conforms to the requirements of the assessment then we will contact you. We can give you a quotation for the repair. Under some conditions the product may be fixed as part of the calibration with no additional charge.

3.2. Shipping

The products in the RT, Inertial+, and Survey+ families are fragile. OxTS will only ship these products in our packaging in order to minimize the damage. If the product is shipped with a silver transit case then we will return it in the silver transit case with specially designed packaging to protect the product from damage. If it is shipped without a silver transit case, then we have a special foam and cardboard shipping set that will be used to return the product. If different packaging is used to ship the product to OxTS then we will dispose of this packaging.

The figure below shows the silver transit case with its special protective foam padding. On the right the cardboard packaging that is used to ship the inertial products from OxTS can be seen.

If the silver transit case is not available then we have a special cardboard replacement for the silver transit case. This can be seen in the figure below.

Normally we will use FedEx for shipments. Shipments with FedEx do not require special packaging to resist water. We do not have suitable packaging for shipments that require protection from water ingress.

When shipping the products to OxTS please note the following.

- If the silver transit case is available then please use it.
- If the original cardboard packaging is available then please use it with the silver transit case.
- If the original cardboard packaging is not available then please package the silver transit case inside another cardboard box. Surround the silver transit case with bubble-wrap or foam so that it fits tightly inside the cardboard box. There is little protection if the silver transit case can move inside the cardboard box; in fact this can make the shocks worse. The foam or bubble-wrap should be at least 5cm thick.
- If the silver transit case is not available then it is best to use two cardboard boxes. Package the inertial navigation system in bubble-wrap and fit it tightly inside the smaller cardboard box. Surround the cardboard box with more bubble-wrap so that it fits tightly inside the larger cardboard box. At least 10cm of bubble-wrap is needed around the inertial navigation system in total. Make sure that everything is packed tight enough so that it cannot move about; movement can make shocks worse.
- Please do not use foam chips in packages sent to us.

Note that shipping is always a risk and the shipment should be insured.

3.3. Timescales

Certain times of the year are busier than others for calibrations. In particular the Christmas period is very busy and we are not able to accommodate all the demand at this period of time. In order to try and be fair we operate a booking scheme for calibrations. We have a target of shipping pre-booked

calibrations within 7 working days of receiving them. For non-booked calibrations we have a target of shipping within 15 working days.

There are some conditions on these targets.

- The product must arrive within 2 days of the booked date (i.e. within a span of 5 days).
- The purchase order and other administrative paperwork must be organised in advance.
- If a repair is needed then the target will be longer. A quotation and purchase order for the repair will be needed.
- If an export license is required then this must be organised in advance.

3.4. End user information

For ISO 17025 it is important that the "Export Control End-User Information" is correct on the order acknowledgement from OxTS. This information will be used on the ISO 17025 certificate. If there are errors in this information then they may be expensive to fix at a later date.

The consignee will be entered as the person placing the order on OxTS.

3.5. Export licenses

The products are classified as "dual-use", meaning that they have both civilian and military applications. This is because the accelerometers that are contained in the products are so accurate that they can be used for missile guidance.

3.5.1. EU countries

The products can be shipped within the EU without any specific paperwork. OxTS needs to know the end application of the product and we are not able to ship the product if we suspect that it will be used for some military or terrorism purposes.

3.5.2. CGEA countries

The EU export laws allow OxTS to ship the products to some countries on an open export license. To use this license we need to know the end application of the product and we are not able to ship the product if we suspect that it will be used for some military or terrorism purposes.

The countries that are currently covered by the CGEA open general export license include Australia, Canada, Japan, New Zealand, Norway, Switzerland and the United States.

3.5.3. Other countries covered by our OGEL

The UK government operates an open general export license (OGEL), which OxTS is registered to use, that allows us to return products after repair (including calibration) to some countries. We can only return the goods to the person who sent them to us. We cannot use this license for "Customs Free Zones".

Countries who can benefit from this license include South Korea, Brazil, Israel, etc. (The list is long so many countries can use this license.)

3.5.4. Other countries

Significantly India, China and Serbia require a new export license even if the goods are returned for repair or recalibration. Other countries may also require a license. We strongly advise customers to obtain an export license before shipping the products to OxTS.

3.6. Customs

OxTS will take care of the customs clearance in the UK provided that the goods are shipped with FedEx. Customs clearance through other brokers is possible but we must be informed before the goods are shipped. Customs in the UK are fairly easy to comply with as long as all of the paperwork is correct; it is virtually impossible to fix mistakes once they have been made. Any charges sent to OxTS because of failure of the customer to make correct declarations will be passed on to the customer.

3.6.1. Foreign customs

OxTS is not able to help with customs clearance in foreign territories. This will be the responsibility of the customer. OxTS is able to help with additional paperwork to make it easier to clear foreign customs. This might include EUR1 forms, etc.

3.6.2. Value for customs purposes

It is essential to use a realistic value for customs purposes. OxTS makes many imports and exports of these products and UK customs will not accept products if they are highly over-valued or under-valued. Putting a low value on the commercial invoice to avoid or reduce duty cannot be supported by OxTS.

It is very hard to value a specialised product. These products are rarely sold on the open market and so a market value does not exist. In order to value the product, consider the following:

- As a simple approach, OxTS will accept a value on the commercial invoice that is half the retail price for products that are over 1 year old.
- Another approach would be to use the value that your company has for the fixed asset. Normally this would depreciate by about 15% per year.
- If you use a different value then OxTS may have to ask for justification (e.g. a realistic depreciation scheme). Or we may have to return it to you with a much higher value.
- The value you use will be used for any insurance claim. OxTS cannot make up the short-fall between the insured value and the replacement value.

4. Addendum

We hope that this has been an informative document on calibration of OxTS products. If you have any questions about calibrations then we would be very happy to help. Please email support@oxts.com.