Survey QAQC, SCC & MSA Quick Start Guide

Rev 1.2
# Contents

Introduction ................................................................................................................. 3

1.0 - QAQC Module .................................................................................................... 4
  1.1 - Required Inputs ............................................................................................... 4
  1.2 - RAW survey QC Limits .................................................................................. 4
  1.3 - QAQC calculation and Outputs ....................................................................... 5
    1.3.1 - Calculation: .............................................................................................. 5
    1.3.2 - Outputs: ................................................................................................. 5

2.0 – Short Collar Correction Module ............................................................................ 6
  2.1 - Magnetic Calculator ....................................................................................... 6
  2.2 - SCC Limitations ............................................................................................. 8
  2.3 - Running SCC .................................................................................................. 9

3.0 – Multi-Station Analysis (MSA) Module ................................................................. 10
  3.1– MSA Setup ..................................................................................................... 10
  3.2 - Running MSA ................................................................................................ 11

4.0 - QAQC, SCC & MSA Reports & Outputs ............................................................... 12
  4.1 – QAQC & SCC Report .................................................................................... 12
  4.2 – MSA Report .................................................................................................. 13
  4.3 – MSA Charts & Data Tables ............................................................................ 14
    4.3.1 – LSQ Data Table ....................................................................................... 14
    4.3.2 – Azimuth Comparison Chart .................................................................... 14
    4.3.3 – HL Comparison Chart ........................................................................... 15
    4.3.4 – Dip Comparison Chart ........................................................................... 15
    4.3.5 -BH BV Scatter Plot .................................................................................. 16
    4.3.6 – LQS Chart ............................................................................................. 16
Introduction

The following document is a guide to Innova's QAQC, Short Collar Correction (SCC) and Multi Station Analysis modules within Innova Engineering.

The purpose of this document is to guide a new user through the layout, setup, calculation and outputs for these modules.
1.0 - QAQC Module

This module takes raw data from the MWD accelerometer (GX, GY & GZ) and magnetometer (HX, HY & HZ) and checks the generated outputs against the local geomagnetic data to ensure that the survey falls within accepted tolerances.

1.1 - Required Inputs

In order to run the QAQC check, the following inputs are required.

- **RAW Survey Data section** of the Surveys tab
  - Latitude: Required to calculate the SCC Delta Azi in the Magnetic Spacing Calculator
  - HL Ref – Reference magnetic field
  - Dip Ref – Reference magnetic dip angle
  - TAC – Total Applied Correction - Automatically calculated based on North Reference selected
  - Grid convergence – Angle between True North & Grid North from True North
  - Declination – Magnetic declination - Angle between True North & Magnetic North from True North
  - North reference – The north reference the surveys are referenced to. Either True or Grid.
  - This data is generally obtained from the well planning department who generate the data using programs like IGRF, BGGM & HDGM.

- **Magnetic Units** associated with HX, HY & HZ
  - Geolink / Tensor: Millivolts (mV)
  - SPP / SUCOP: Micro Tesla (µT)
  - nT: Nano Tesla (nT)

- Raw data from the MWD tool (GX, GY, GZ, HX, HY & HZ) + Measured Depth

1.2 - RAW survey QC Limits

It is important that the correct QC limits are set. These values are the ± limits used to compare the measured values against the calculated values. If these limits are not accurate it is possible that surveys may pass, which should not pass and conversely surveys may fail, which should actually pass.

The QC default limits set in Engineer are industry standard. It is however possible to change these if required. You can do this as follows:

- In the Surveys tab, select Raw Surveys from the Survey Selection drop down.
- Select Options from the top toolbar and then Raw Survey QC Limits.
- Note, that you can only access these values when you have Raw Surveys selected.
- Individual limits can now be changed as required.
- Note, that any changes made to these limits will only be valid for each specific project. When creating a new project, limits will be the default values until changed.
1.3 - QAQC calculation and Outputs

1.3.1 - Calculation:

- Ensure that the correct units have been selected, fill in the RAW Surveys Tab data (HL, Dip etc) and ensure that you have the correct RAW survey QC limits assigned.
- Ensure that you have the correct survey calculation method selected: **Options - Survey Calculation Method.** The default is **Minimum Curvature** and is very unlikely to be anything other than this.
- Select **Raw surveys** from the survey selection drop down menu.
- You can now enter your raw MWD data on a survey by survey basis, or if you are retrospectively checking an existing survey you can add the whole thing in one go
  - You can copy and paste the data, or
  - Go to **File - Import Survey** - you can then select the file you want to import
  - Note that in the drop down file type menu, there is an option that says **Navigator SCC .txt** - This should be used when importing Navigator export files (Navigator export files also contain the Geomag data, once imported ensure the Geomag data that has been pulled in is correct)

1.3.2 - Outputs:

The generated HL, GT and Dip values are compared to the reference data in the RAW surveys Tab and any of the generated values out with the selected QC limits will be highlighted in **RED**. For a survey station to pass the QAQC procedure, they must fall within the QC limits and therefore not be highlighted.

Any surveys which have been highlighted should be rejected and retaken, **unless** it is possible to use the Short Collar Correction (SCC) algorithm to correct them to within the accepted limits.

![Example Image](image-url)

The values in the SCC column's will be generated regardless of whether a survey passes QAQC or not, and should therefore be disregarded, unless of course you are using the correction.
2.0 – Short Collar Correction Module

Short Collar Correction (SCC) corrects for magnetic interference in the Z axis. It should be noted that for the short collar correction algorithm to work correctly the Z axis must be aligned with the hole direction i.e. the Z axis points along hole. If this is not the case the short collar correction algorithm will not work. All major MWD companies with the exception of Schlumberger have the Z axis aligned with the along hole direction.

2.1 - Magnetic Calculator

Firstly, you need to ensure that the following data has been added to Engineering.

- Proposed BHA with the relevant components marked as non-magnetic
- Well Plan, in the Surveys Tab under Well Plan Surveys
- Raw Survey Data section and Sensor offset in the Survey Corrections section

You can now calculate the well path magnetics: Calculate - Wellpath Magnetic Interference or 

A window will now appear with the results and will look like the screen shot below.
Results

- **Azimuth**: The azimuth displayed is referenced to **Magnetic North**, and will therefore look different when compared to the azimuth that was entered in the plan (which could be referenced to Grid or True North). The correction applied to the input azimuth is automatic and is based on the Geomagnetic data that you have entered in the Raw survey Data Section.

- **Theoretical Bz**: The theoretical magnetic field strength expected in the Z axis with no interference.

- **Delta Bz**: The expected error between the **Theoretical Bz** and the Measured Bz (from MWD) for raw, uncorrected surveys.

- **Delta Dip**: The expected error between the calculated dip (from the geo-mag data) and the actual measured value (from MWD).

- **Delta HL**: The expected error between the calculated magnetic field strength (from the geo-mag data) and the actual measured value (from MWD).

- **Delta Azimuth**: The expected error in the raw uncorrected azimuth reading, <0.25 degrees is considered acceptable

- **SCC Delta Azi**: The expected error in the SCC corrected azimuth, <0.25 degrees is considered acceptable

These results can be used to make an informed decision as to whether there is a requirement to run the SCC algorithm, add additional non-mag or do nothing. Company policy will dictate what error values are considered acceptable.
2.2 - SCC Limitations

When it is deemed necessary to run SCC, careful consideration should be given to the planned well path, as there are defined limitations to the SCC which must be adhered to. Failure to follow these guidelines could result in surveys passing correction which should not. The SCC limits are listed in the table below.

<table>
<thead>
<tr>
<th>Inclination Range (Deg)</th>
<th>Azimuth Range (Deg)</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-60</td>
<td>0-360</td>
<td>No Limitations</td>
</tr>
<tr>
<td>60-90</td>
<td>0-60, 120-240, 300-360</td>
<td>No Limitations</td>
</tr>
<tr>
<td>60-90</td>
<td>60-70, 110-120, 240-250, 290-300</td>
<td>See Note (1)</td>
</tr>
<tr>
<td>60-90</td>
<td>70-110, 250-290</td>
<td>See Note (2)</td>
</tr>
</tbody>
</table>

- **Note 1** – If possible, SCC should NOT be used and the BHA should be correctly spaced with non-magnetic tubulars as required.
- **Note 2** – SCC must NOT be used if the well path is known to be within these parameters. Again, the BHA should be correctly spaced with non-magnetic tubulars as required.
- If the above parameters are encountered, then the SCC algorithm will not function correctly and erratic corrected data will be seen. It is therefore necessary to discuss beforehand with the Directional Driller/Company Representative as to an agreeable plan of action if the above criteria are expected to be encountered during the drilling that particular borehole.

If the planned wellbore falls out with the above limitations, SCC should NOT be used, and you should ensure that the BHA has the correct non-mag spacing.
2.3 - Running SCC

When running the SCC, raw survey data is added in the same way as you do for the QAQC.

As with the QAQC, any numbers which are out of spec are highlighted red and should not be used. However, there are 3 columns (Azi SCC, HL SCC & Dip SCC) which contain corrected values, and as long as all 3 of these columns are not red, the **Azi SCC** value can be used instead of the calculated azimuth.

If even one of these 3 cells are red, the corrected azimuth should not be used and the survey should be retaken.
3.0 – Multi-Station Analysis (MSA) Module

Multi Station Analysis is a technique which can be used to calculate Magnetometer biases in the X, Y & Z axis. This is achieved by examining the measured and theoretical values at each sensor over multiple stations to find corrections which minimise the errors. These corrections are then applied to all the raw values to produce corrected surveys.

3.1 – MSA Setup

This section will assume that the user has input all data required to run SCC, as these steps must be complete before MSA can be calculated.

- In the Surveys tab on the main screen, select the MSA radio button located at the bottom right of the screen – This will open the Multi Station Analysis window.
- All the RAW surveys populated on the main screen can be found here – Note that these inputs are NOT editable on this page.

- The HL Ref box located at the top left of the screen will contain the value entered on the main surveys tab. This can however be changed on this screen if a more accurate value is supplied e.g. from an IFR model.
- MSA Parameters: The user can select the required Bias and SF start, stop and Step values. If the LSQ fit does not show a good curve with a minimum found these values can be adjusted to extend the range of the calculation. Changing the step size can speed up / slow down the calculation but a smaller step size can increase the accuracy.
- Values in Use: The user can choose which values to use for the calculation:
  - Bz: Choose between SCC or raw. This determines which Bz value is used in the MSA calculation. If there is a large amount of interference in the Z axis, select the SCC option as the Z axis interference from the drill string must be removed before the MSA calculation can be run. If, however the BHA is correctly spaced or the assembly is run in the SCC no-go zones, then the raw value should be used.
  - Azimuth: This selection determines which azimuth is used in the survey calculation and only affects TVD, NS, EW, DLS etc
  - Inclination: This selection determines which inclination is used in the survey calculation and only affects TVD, NS, EW, DLS etc
- Apply Gt Weighting: Surveys at a higher inclination are given more weighting in the calculation than surveys at lower inclinations. This is because they have more of an effect on azimuth. Ticking this box defines if the weighting is applied.
3.2 - Running MSA

To run the MSA calculation, select the “Calculate MSA” radio button. The MSA columns will populate with the relevant corrected values. As with the SCC results, anything out of spec will be highlighted in red.

At the left-hand side of the screen, if required the user can deselect any survey station which is out of spec. Once the relevant surveys have been deselected it is possible to rerun the calculation. The lines which have been deselected will have blank cells in the MSA columns, and this station will not be included in the calculation.
4.0 - QAQC, SCC & MSA Reports & Outputs

The MSA report and output charts are separate from the QAQC and SCC reports.

4.1 – QAQC & SCC Report

Once a calculation has been run, if required the user can generate a report. This can be done by either selecting the Report icon or by going to File - Print Reports.

Select the Surveys tab and select raw surveys. It is possible to create the report as PDF or Excel. Then select File - Print.
4.2 – MSA Report

The MSA reports are accessed directly from the MSA window and are NOT available from the Print Reports section. Once MSA has been calculated the user can select File – Print Report.

This generates a PDF report which includes the MSA results, Magnetics, Pseudo Bias & SF values and a listing of the corrected surveys. Note that any stations which were deselected will not appear in this listing.

The user can also export the main MSA data table, as displayed on the main MSA interface. This can be exported as a .txt or Excel file. To export this data, select File – Export.
4.3 – MSA Charts & Data Tables

In addition to the reports, there are additional outputs available for the MSA. These can be accessed by selecting View from the top menu bar.

4.3.1 – LSQ Data Table

The LSQ Data table shows the data from the least squares fit.

<table>
<thead>
<tr>
<th>BLAS</th>
<th>SCALE FACTOR</th>
<th>LSQ BX</th>
<th>LSQ BY</th>
<th>LSQ BZ</th>
<th>LSQ SZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>0.0000000000</td>
<td>0.5338</td>
<td>0.9999</td>
<td>0.5385</td>
<td>0.5385</td>
</tr>
<tr>
<td>950</td>
<td>0.0000000000</td>
<td>0.5335</td>
<td>0.9999</td>
<td>0.5385</td>
<td>0.5385</td>
</tr>
<tr>
<td>900</td>
<td>0.0000000000</td>
<td>0.5335</td>
<td>0.9999</td>
<td>0.5385</td>
<td>0.5385</td>
</tr>
</tbody>
</table>

4.3.2 – Azimuth Comparison Chart

The Azimuth Comparison chart, provides the user with a visual representation of the Uncorrected azimuth against the SCC corrected azimuth and the MSA azimuth.
4.3.3 – HL Comparison Chart

The HL comparison chart gives the user a visual representation of the reference HL against the measured (uncorrected) HL and the SCC & MSA corrected HL values. The chart also includes the tolerance lines which make it very easy to quickly identify any points which are out with the QC parameters.

4.3.4 – Dip Comparison Chart

The Dip comparison chart gives the user a visual representation of the reference Dip against the measured (uncorrected) Dip and the SCC & MSA corrected Dip values. The chart also includes the tolerance lines which make it very easy to quickly identify any points which are out with the QC parameters.
4.3.5 - BH BV Scatter Plot

The BH BV Scatter Plot shows the horizontal and vertical components of the sensor readings plotted against the QC values. Ideally, they should all reside within the limits.

![BH BV Scatter Plot](image)

4.3.6 - LQS Chart

The LQS Chart shows the least squares fit. If a V shape curve is seen the minimum has been found and the calculation is a success. If any one of the charts does not show a “minimum found” the calculation must be re-run.

![LQS Chart](image)