**ELLIPSE OF UNCERTAINTY**

**SCIENTIFIC DRILLING’S ISCWSA ERROR MODELS**

### ERROR MODEL

<table>
<thead>
<tr>
<th>Well Location</th>
<th>Model</th>
<th>Type</th>
<th>µ</th>
<th>σ</th>
<th>σ0</th>
<th>σR</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Sea</td>
<td>Seafarer</td>
<td>0.67</td>
<td>17.9</td>
<td>36.4</td>
<td>4.4</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td>Standard</td>
<td>0.67</td>
<td>17.9</td>
<td>36.4</td>
<td>4.4</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td>SVM/EH/30</td>
<td>0.67</td>
<td>17.9</td>
<td>36.4</td>
<td>4.4</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
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</tr>
</tbody>
</table>

All survey error models calculated at 0° azimuth.

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**ACCURACY MATTERS**

*Are you certain you have the right survey provider?*

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**CORPORATE HEADQUARTERS**

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**THE ULTIMATE PARTNER IN WELLBORE PLACEMENT**
01 HOW DO YOU CALIBRATE YOUR GYRO SENSORS & HOW OFTEN IS THIS DONE?
Scientific Drilling’s gyro survey instruments are calibrated using a rigorous process at our manufacturing facility. The calibration process involves development and validation of a “calibration file” for the tool ranging around 75 hrs to complete. The file comprises over 90 parameters which model the physical behavior of every tool component. Many of these parameters are temperature-dependent, which means that they are modulated over our entire operating range with a complex formula, containing dozens of coefficients.

02 HOW DO YOU DETERMINE IF YOUR SENSORS REQUIRE CALIBRATION?
Each District Office contains precision gyro calibration check stands that are accurately aligned to true north. Before and after each job, each tool is checked in these stands to verify tool performance across its entire operating temperature range. Once onsite, pre- and post-job field calibration checks ensure key sensor parameter are still within acceptable ranges. If any parameter is found to have drifted from the personality file value, the tool is returned to the manufacturing facility for recalibration.

03 WHAT ARE YOUR QA/QC MEASURES?
There are several QA/QC measures in use by Scientific Drilling’s gyro survey system.

04 DOES YOUR GYRO MEASURE EARTH RATE, IF SO, HOW IS IT COMPUTED?
SDI’s Keeper tools do measure Earth Rate, during its north-seeking operation. Earth Rate can be computed using the formula 15.041 * cos(latitude).

05 HOW DO YOU KNOW IF YOUR TOOL IS WORKING PROPERLY ON LOCATION?
The QA/QC measures mentioned above ensure that the tool was working properly, and enable the surveyor on location to verify the accuracy of the survey, or call a mission immediately if something went wrong.

06 WHAT LEVEL OF EXPERIENCE AND TRAINING DO YOUR SURVEYORS HAVE?
SDI surveyors undergo a comprehensive training program – including an intense school conducted at a test well in various locations around the world. Many of our surveyors have been running tools for decades and have operated survey tool of various types since they were innovated. In addition to learning how to operate the tools and perform quality checks on surveys, our surveyors are fully trained on the theory and mechanics of gyroscopes and our other technologies.

07 HOW ACCURATE IS YOUR SURVEY TOOL AND HOW IS THIS VERIFIED?
The accuracy of Scientific Drilling’s gyro tools are dependent on a variety of factors, and is modeled in the standard ISWCA format. Our Keeper gyro is the most accurate tool available, and can eventually be pointed at an absolute heading to within 0.5°.

08 DO YOU HAVE AN ISWCA ERROR MODEL FOR YOUR SURVEYS?
Yes, and in fact Scientific Drilling has different models depending on how the tool is run such as wellsite survey, deep gyro, etc., in order to ensure accuracy. SDI is an founding member of ISWCA, and played a key role in the development of the first ISWCA models.

09 WHO VERIFIES YOUR ERROR MODEL & HOW IS THIS ACCOMPLISHED?
SDI uses several methods for validating its error models. First, the models are subjected to mathematical validation, where specific parameters are varied using scientific analysis of the tool performance. Next, these parameters are varied through rigorous analysis of the tool’s calibration records. Every tool that comes through the factory contributes to the validation of Keeper error models. And finally, we run hundreds of test surveys in wells around the world to show repeat performance of our systems within our error models.

10 WHO MANUFACTURES YOUR SENSORS & WHAT APPLICATIONS ARE SUPPORTED?
SDI manufactures our own accelerometers and gyroscopes at our Applied Technology Center located in Paso Robles, California.

SDI was founded by a group of experts from the aerospace industry who designed and built missile guidance systems for the US military during the cold war. They used their experience to develop a new gyro that met the specific needs of onshore surveying. This sensor eliminated dependency on government missile contracts, and enabled SDI to design sensors that met the downhole need perfectly.

The sensors are designed and built only for use in SDI’s Keeper and not adapted from some other use. This ensures optimal performance in the downhole environment and allows us to constantly measure the quality of our final product.